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Preface

DASCOH's work in water and sanitation is based on close and systematic observation of the communities that we serve. Over the years, our Research and Monitoring Unit has grown its dialogue and survey capacities. We believe that its databases provide us with valid and reliable measures of the initial needs of the population, the progress we make against the targets of the projects as well as the desired outcomes visited at the mid-term or final stages.

This holds also for the Sustainable Solutions for the Delivery of Safe Drinking Water (SDSD) project. We began this endeavor *"to contribute to equitable and sustainable access to jointly managed water and sanitation services through improved local governance"* in 2004, in the districts of Rajshahi and Chapai Nawabganj in western Bangladesh. In 2010, the Swiss Agency for Development and Cooperation (SDC) invited us to extend the project to the northeastern district of Sunamganj in Sylhet Division. Operational since early 2011, the project has, by the end of 2012, installed close to 900 tubewells providing safe water to an estimated population of 84,000. It installed close to 3,000 sanitary latrines used by about 20,000 people.

As important as those figures are, this study is not about what DASCOH has achieved in Sunamganj. Rather, it is a deep X-ray of the kind of task environment that an NGO like ours encounters in a poor, disadvantaged region. The leading question is to what extent poverty alone is responsible for unmet needs, as opposed to the restraining effects of remote and isolated locations that would operate even in the absence of extreme poverty. This is of immediate interest in the perspective of sustainable development: what needs to be done in order to secure gains in water and sanitation (and other fields) so that they persist - not only in the face of material deprivation, but also in locations removed from administrative and commercial centers?

While similar questions have been investigated by researchers before, it is important to note that this study did not involve separate data collection efforts, but relies on the water and sanitation inventory routinely undertaken for our operational needs. We want to demonstrate that such data can be put to analytic use beyond normal monitoring purposes (which we satisfy in our project reporting). The study team uses statistical methods that uncover relationships among communities, technologies and institutions that are not usually made transparent outside academic research programs.

Its findings reinforce DASCOH's philosophy that local government institutions are best suited to provide and ensure doorstep services for grassroots people. To ensure quality services, we work to improve the transparency, accountability and responsiveness of institutions up and down the local administrative ladder. The study reminds us that the sustainability, particularly of safe water facilities, will remain challenging. Yet it also works out that water and sanitation enjoy a degree of autonomy vis-à-vis other institutional arenas, which both DASCOH and its stakeholders in Sunamganj can use in order to make effective and robust improvements.

Md. Akramul Haque, CEO, DASCOH

[Background:] DASCOH and SDSD

The Swiss Red Cross (SRC) founded the Development Association of Self-reliance, Communication and Health (DASCOH) in 1994. In 1995, the NGO Affairs Bureau of the Government of Bangladesh registered DASCOH as an international NGO under "The Foreign Donations (Voluntary Activities) Regulation Ordinance, 1978". At present, DASCOH is in the process of transforming itself into a Bangladeshi NGO.

With financial support from SRC and from the Swiss Agency for Development and Cooperation (SDC), DASCOH has been operating projects in the water and sanitation sector (WatSan) since the late nineties, largely in response to the arsenic water contamination crisis. The WatSan sector has served as a bridge to an increasing engagement with governance questions, at the lowest level of local government (the so-called Union Councils) and in the villages that consume Council services.

DASCOH's head office is in Rajshahi, in the western region of Bangladesh. There it conducted the Sustainable Solution for the Delivery of Safe Drinking Water (SDSD) project in 17 Unions in two districts between 2004 and 2012. In 2010, the SDC invited DASCOH to extend the SDSD to select areas of the Sunamganj District, in the northeastern region.

Here, since 2011, the project has been active in 25 Unions in four sub-districts, currently with a staff of 35. It conducted a baseline survey in a sample of villages in summer 2011, followed by a WatSan inventory in all villages in winter 2011-12. The inventory data form the basis for this study.

The specific objectives of the Sunamganj SDSD are:

- to support local government and communities to improve water resources as well as sanitary and hygiene management while institutionalizing improved local governance processes and taking into account the different realities of women, men and very poor households (outreach target: 700,000 direct beneficiaries).
- to promote knowledge transfer, replicate best practices and ensure the stepwise handing-over of management tasks to local partners (communities and local government).

In the wider context, the project supports the Government of Bangladesh in achieving its Millennium Development targets on water and sanitation by 2015.

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The following DASCOH staff members were instrumental in collecting and processing data and/or in collecting and interpreting case study material:

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Acronyms and expressions

ASD	Assistance for Slum Dwellers, a Bangladeshi NGO
CBO	Community-based organization
CLTS	Community-Led Total Sanitation
DASCOH	Development Association for Self-reliance, Communication and Health
DPHE	Department of Public Health Engineering
hati	hamlet (in the Sunamganj context; elsewhere: *para*)
HH	Household, households (in statistical tables)
LGED	Local Government Engineering Department
NGO	Non-governmental organization
PVC	Polyvinyl chloride, a plastic, used also in tubewell piping
SDC	Swiss Agency for Development and Cooperation
SDSD	Sustainable Solutions for the Delivery of Safe Drinking Water
sq km	Square kilometer
SRC	Swiss Red Cross
STATA	A statistical package
Taka	Bangladesh currency. US$ 1 = approx. Tk. 80
UNICEF	The United Nations Children's Fund
Union Parishad	Union Council (lowest local government body)
Upazila	Sub-district
WatSan	Water and sanitation

Summary

DASCOH, a Bangladeshi NGO with a track record in water and sanitation, has long been working with small local communities as well as with the concerned local governments mandated to make improved access and use sustainable. DASCOH's community-based inventories provide detailed statistics of existing facilities and practices. They permit gauging the relative influence of household poverty versus locational factors on differential WatSan endowments. The fact that these differences depend not only on local poverty levels, but on other location-related factors is not unusual; it was observed by development researchers for other household welfare measures as well.

We use the data from a recent large inventory that DASCOH workers carried out in the northeastern region of Bangladesh to estimate the respective effects. We investigate access to WatSan facilities (safe water, hygienic latrines) and, for comparison purposes only, to services in two other institutional spheres (post-primary education, health care). Across these three domains, we find that both poverty and location are significant determinants. We define access indicators and measure them through the compositional and geographic attributes of 988 villages and hamlets. Ratios of middle-class and rich households, members working overseas and adults with higher than primary education describe the wealth and poverty of communities. Distance from commercial centers and depth of tubewells index their positions in the locational system of service delivery. Finally, variations in access to services by Unions (local government areas) and by electoral Wards reveal the finer structure of local factors.

We find that for the villages themselves the socio-economic composition has a stronger effect[1] on WatSan outcomes than locational factors do. This imbalance is less pronounced for access to post-primary education. In health care, for which our only measured indicator is the cost of transport to and from a point of diagnosis and drug sale, chiefly location matters. Patients from richer and better educated villages afford transport that is only slightly more expensive - in other words, richer patients do not travel for primary care to farther places that might offer more sophisticated providers.

We compare the strength of village-level effects on service outcomes to the effects of Wards and Unions. Their relative strength varies across service domains. Village-level effects are strongest on safe water provision and on post-primary education, and weakest on health care access. Union effects are strongest on the diffusion of latrines, including simple and unhygienic latrines, and almost as strong on education. They are comparatively weak on safe water access.

[1] Throughout this report, the primary understanding of "effect" is statistical. The statistical effect is the value of the explanatory variable multiplied by its coefficient estimated in a regression model. Retranslated into ordinary language, the "effect of education on sanitation" simply means "more education lets us expect more hygienic latrines". We do not concern ourselves with differences among outputs, outcomes and impacts, such as in "more latrines - better hygiene - lower morbidity". A WatSan inventory reveals who has more latrines, who has fewer - not who lives longer, who dies sooner.

Ward effects are particularly strong in health care and are strong in sanitation. Wards have institutional effects (through elections and the function of Ward committees in Union budgeting) as well as locational ones (such as when entire Wards are cut off by seasonal flooding). In service areas with strong Ward effects, the balance between poverty and locational influences is further shifted towards the latter.

Figure 1: A village WatSan inventory meeting

In a third analytic step, we observe how the estimated effects at the village, Ward and Union levels are correlated among service access indicators. Between the DASCOH's two main promotion fields - safe water and hygienic latrines -, the correlations are strong at all levels. Between WatSan and post-primary education, the effects are strongly correlated at the village. At the Ward and Union levels, the correlations are still positive, but much weaker. Effects on health care access are weakly or not at all correlated with effects on all other service areas, across levels.

Three consequences emerge in the interpretation of findings:

- **Institutions:** Household poverty and remoteness of settlements alone do not tell the story of service access. Strategies need to look at poverty, location and also institutions. While isolation is most clearly a property of small local settlements, and formal institutions are more elaborate at higher administrative levels, they interact strongly at Union and Ward levels. Therefore, assessments (including WatSan inventories) and programming need intermediate institutions such as Union Councils as much as with end users in the villages. DASCOH systematically works with these intermediary entities.

- **Program coherence:** The strength of village-level effects, compared to Ward and Union effects, in safe water provision makes it more difficult for these assets to survive in a self-sustainable manner, against the odds of poverty and remoteness in many target communities. DASCOH strives to release this constraint by helping Union Councils and user groups to set up and practice maintenance routines. The fact that villages, Wards and Unions with better safe water provision have tended to make wider use of hygienic latrines as well should facilitate a coherent WatSan approach.
- **Local cooperation:** The fact that *Union* and *Ward* effects on water and sanitation are positively, but weakly correlated with those in other service domains makes for greater autonomy of WatSan service providers. Thus, where DASCOH finds the right match with eager Union Councils and Ward committees, it can pursue its objectives almost independently of what providers in other service areas are doing. But it cannot override *village* conditions. If, for example, a village has been left out from post-primary education, the factors hampering education, whatever they are, will likely work also against the long-term sustainability of WatSan assets. Ultimately, it will be up to grassroots institutions to integrate the village-level work of different sector agencies. DASCOH's work with Ward committees and WatSan end-user groups helps to prepare the ground for this.

Our findings support DASCOH's philosophy that WatSan progress is not only a question of poverty reduction in the receiving communities, but also one of building systems of support and maintenance that the agencies responsible for them must be enabled to own and operate. Poverty, location and institutional considerations are woven together.

[Background:] Sunamganj District

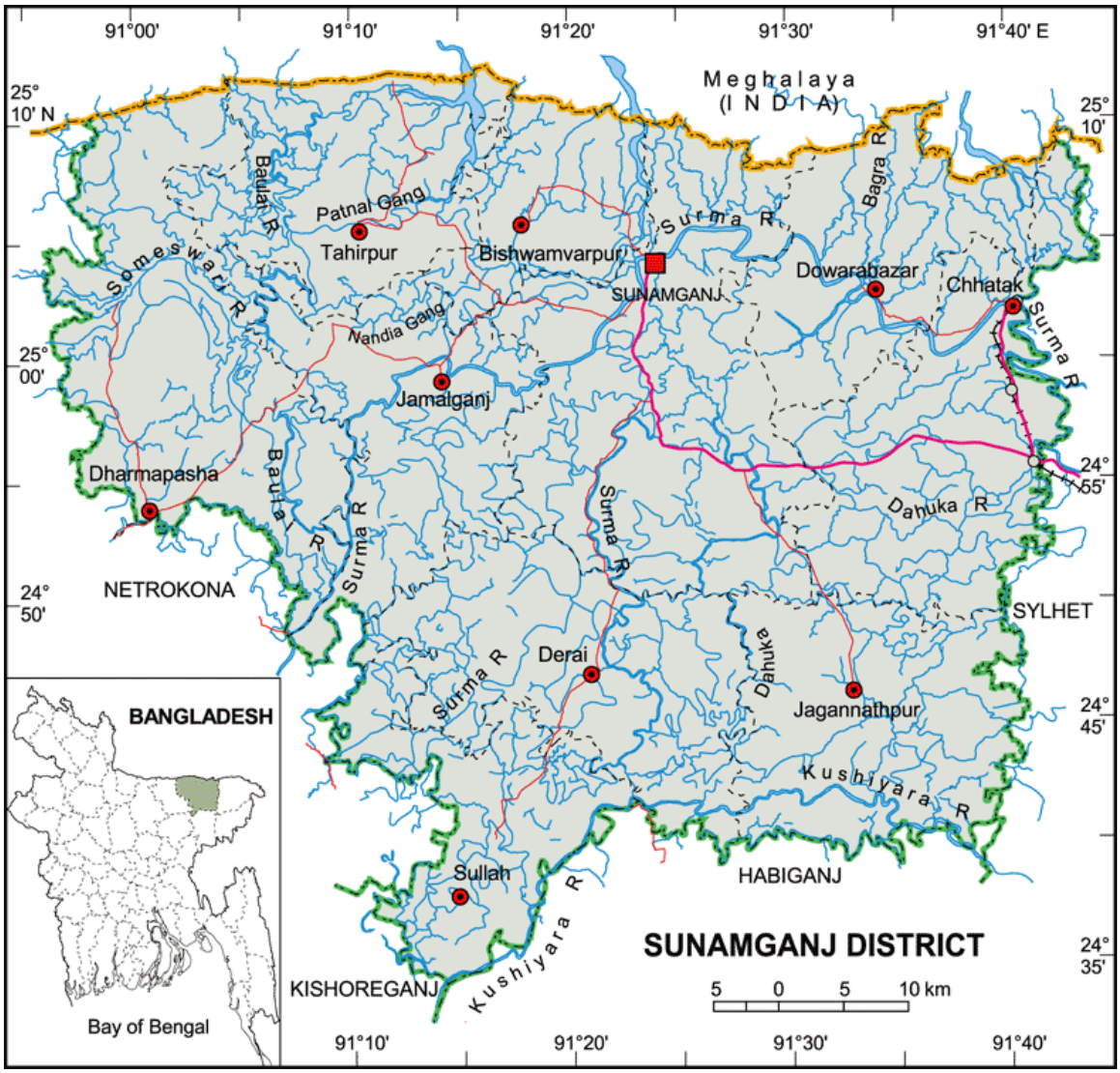
Sunamganj is a district on the northern border with India. In 2001, the census established a population of 2,013,738 residents in 349,558 households. For the 2011 census, those figures were 2,467,968 population and 440,332 households. With a surface of 3,669.6 sq km, the population density intensified from 549 to 659 persons per sq km. The urbanization rate stayed constant at approximately 10.5 percent (BBS 2012: 9).

In agro-ecological terms, large tracts of Sunamganj form part of the greater Sylhet Basin, a region of lengthy and deep seasonal flooding. In socio-economic terms, the district is often shown as part of a large contiguous north-to-northwest poverty belt. For example, the Bangladesh Rural Poverty Mapping Project (Kam and et.al. 2004) places all the Upazila (sub-districts) of Sunamganj, with the exception of Jaganathpur in the south-east, in the highest quartiles of poverty and extreme poverty. The poverty belt is characterized, among other effects, by low irrigation in the dry season, difficult road access to facilities, low educational attainment, and poor quality housing. However, most of these studies use data from the 2001 census or from surveys of similar age.

Settlement is predominantly in the shape of hamlets that occupy available highland above normal flooding. The 2011 census recorded 11 Upazila, 87 Unions (local government areas), 1,535 *mouza* (revenue villages), 2,887 villages and 4 *pourashava* (city government areas). Note that the

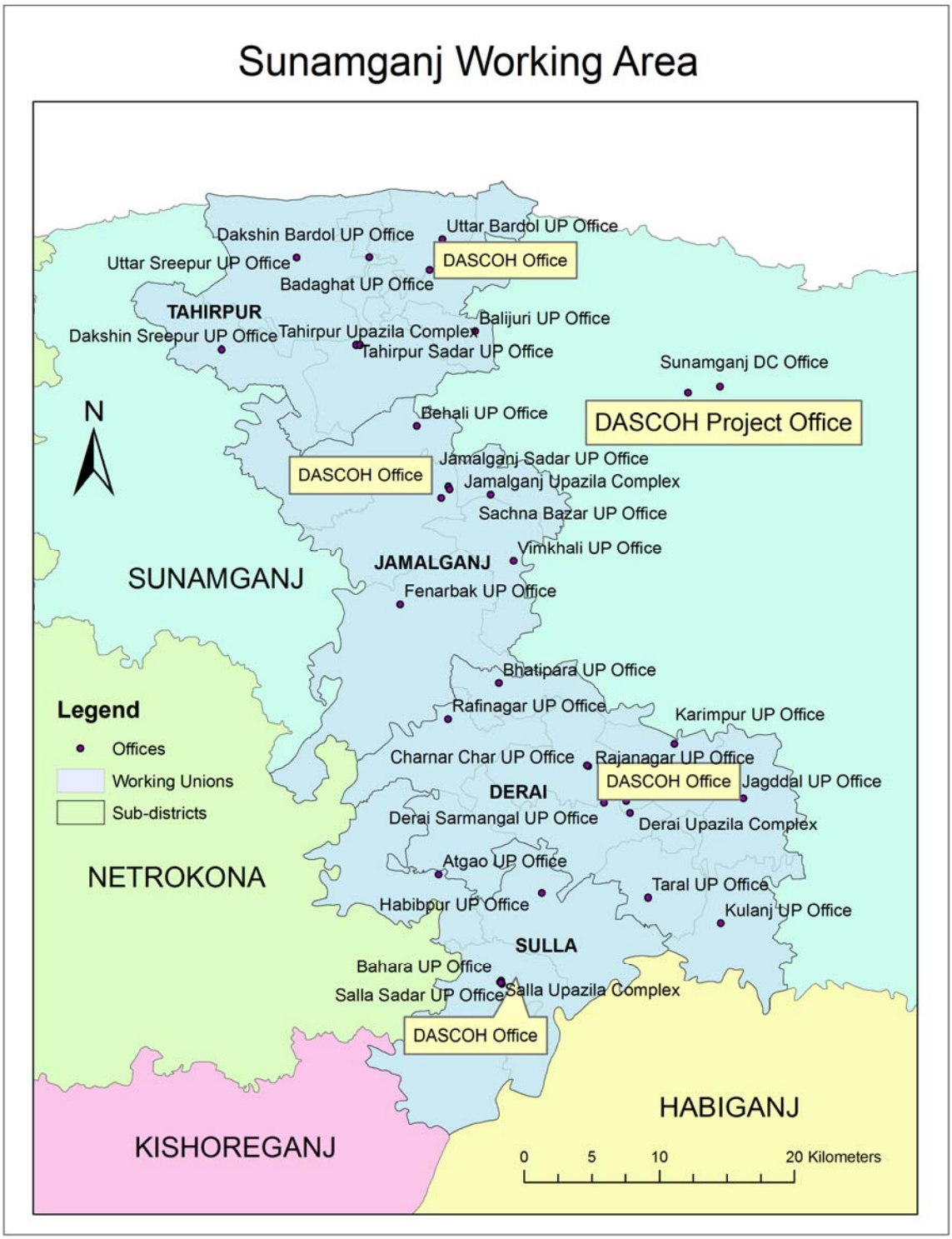
definitions of villages and hamlets are fluid; the pragmatic definitions used by NGOs do not always agree with those of the census or other surveys.

Figure 2: Overview map of Sunamganj District



Source:
http://1.bp.blogspot.com/_Xh4MstvdVIw/TMMtPzwcL3I/AAAAAAAAAL4/toQxAikfDZI/s1600/Sunamganj+District+Map.gif

Figure 3: DASCOH's working area in Sunamganj



Source: Authors

Introduction

What facilitates access to better service more - higher socio-economic status or more favorable location? Is a household more likely to enjoy safe water, good schools for the children, regular transport to work and to markets if it is poor but living in a well-connected community, or rather if better-off, yet secluded in a remote village?

Thus posed, the question is, of course, facetious. These two factors are intertwined, for a number of reasons. Richer households afford residences in good locations; and providers - both private and government - focus services on locations of higher purchasing or political power. Poorer households more often find themselves crammed into less accessible, less convenient, less salubrious places; providers neglect them or cater cheap or low-quality goods and services.

The correlation between poverty and location is not perfect, though. In societies with strong feudal legacies, traditions for richer and poorer (the latter often tenants or workers of the former) to intermingle in fairly close residential quarters persist. In addition, if services originate in a spatially concentrated pattern (e.g., the headquarters town has the only college in the district), friction arises for richer and for poorer users, though perhaps in unequal measure. A strong association between social and physical marginalization is likely in many situations of poverty, but its actual degree is an empirical matter. In every region under study, one has to carefully look at the pattern of residential intermingling of richer and poorer and simultaneously at access to services and livelihoods.

The question is relevant for policy as well. Programs of poverty reduction will have lasting effects only if the newly created services or livelihoods reach the intended participants where they live, work or are willing to migrate to, and if they stay viable (or are a start for something better) after the direct participation ends. Even if the new activity initially was beneficial, benefits will not last if either household capacity or locational factors prove adverse. Equipment that depends on rare, expensive, unreliable or exploitative outside maintenance services exemplifies this generic challenge. One of the implications is that poverty production programs may need to work not only where the poor live, but also where the agents are located who later will provide continuity of service.

This holds for a multitude of regions in developing nations and across different sectors. DASCOH, a Bangladeshi NGO active in the water and sanitation (WatSan) sector, has long realized that it needed to work closely both with the local communities directly benefitting from its inputs and with government and commercial entities ensuring legitimacy, expertise, and continued support. The WatSan inventories that it conducted in the Rajshahi region of western Bangladesh and recently in Sunamganj District in the northeast rendered a detailed, variegated picture of access to safe water and proper sanitation, by household socio-economic status as well as by local community. What has not been done so far is a closer analysis of such data in order to gauge the relative influence of poverty and location on the WatSan situation.

Access to services

The WatSan inventory that DASCOH conducted in close to a thousand villages and hamlets of a contiguous poverty area in Sunamganj in 2011-12 allows us to shine some light on the question. The question is not new; World Bank researchers earlier found *"significant and sizable geographic effects on living standards after controlling for a wide range of nongeographic characteristics of households"* in Bangladesh (Ravallion and Wodon 1999)[2]. And whereas their study relied on detailed household welfare surveys, ours is bound to remain modest. Our data were aggregated to hamlets and villages; household attributes thus appear as count data and, when denominated to households, as compositional variables of settlements. These data are attractive because they are about fully enumerated settlements in the DASCOH working area. Sampling bias against smaller, poorer or more remote settlements is no issue.

We investigate access to services in four areas. Two fall into the WatSan realm in which DASCOH is directly involved: the density of safe water options in the community, and the use of hygienic latrines. We look also at the proportion of households that use latrines of any type, but many of the simple facilities are flooded in the long monsoon season, and unambiguous adoption measures do not exist for them.

It is of more than academic interest to understand whether the determinants of WatSan facility access are the same as, or similar to, those operating in other institutional areas. If they are significantly different, one may assume that the support system for WatSan improvements enjoys considerable autonomy vis-à-vis other institutional systems. In other words, WatSan agencies will have to overcome less of a generalized institutional inertia. They will have better chances to build sustainable support systems even in communities where educational, health care and other institutional initiatives find less favorable conditions.

Therefore, for comparative purposes, we investigate access also to education and health care. With limited survey capacity in this area, we use indicators that imply access to services that, for most communities, are located outside: high school education that benefits their recent adolescents and health care access expressed in terms of medical transport cost. We note upfront that the narrow range of available indicators is unsatisfactory; one would wish that each service area were represented with more than just one access measure. In health care, the cost of transport to a point where a patient (or relatives describing his symptoms) can obtain a diagnosis and drugs, from whatever kind of medical practitioner, is a relevant access factor. The cost is prohibitive for many very poor living in remote villages. We phrased the question as "Where can you buy medicine, and how much does it cost to travel there?" because the attempt to gather the cost of transporting a patient to a minimally equipped health center produced missing values in communities who cannot afford it. But transport is only an input to health care consumption. This limitation is unsatisfactory, but we do not want to use education access as the only comparator to the WatSan models and therefore did use medical transport cost data.

[2] For a worldwide review of the impact of remote rural areas on chronic poverty, see the report by Bird et. al. (2002).

[Sidebar:] What are "safe water options"?

DASCOH's water and sanitation inventories count the "safe water options" to which a surveyed community has access. This study measures the intensity of access by the rate of safe options for every 100 households. It estimates models that predict the number of options as a function of population, poverty, locational factors and of living in particular Wards and Unions.

Thus, what are "safe water options"? DASCOH considers drinking water safe if it is free of micro-organism, worms and noxious chemicals. In Bangladesh, contamination of drinking water with geological arsenic is a major social problem (for an introduction, see Hanchett, Sultana et al. 2006; Atkins, Hassan et al. 2007). Shallow hand and irrigation wells are major sources of arsenic. Tubewells that tap into deeper aquifers are less prone to arsenic contamination, but more expensive. It is assumed that they can disturb previously inert material, causing arsenic to be leached into the water, which therefore ought to be tested periodically. DASCOH considers the following technologies safe for drinking purposes:

- Tubewells
- Tubewells with multi-heads
- Improved dug wells
- Rainwater harvesting
- Sono filters

Tubewells are considered safe if tests for arsenic report a level of less than 50 parts per billion (ppb). DASCOH field-tests all new tubewells and, if they are contaminated, has them re-bored at a distance.

Dug wells are considered improved if their owners disinfect them with bleach twice a year and keep them covered with lids between withdrawals. Dug wells are a popular alternative to tubewells in regions with high arsenic concentrations.

Sono filters are a government-approved home-based device for the removal of arsenic and iron.

In the DASCOH working area in Sunamganj District, the baseline survey in 2011 found that 96.3 percent of the sample households were using tubewells as their dry-season source of drinking water. A mere 0.1 percent relied on dug wells (of unknown quality); 0.2 percent drank collected rainwater; and 3.5 percent collected their drinking water from ponds, river and canals. Sono filters were not encountered. The lack of tubewells is concentrated in a minority of local communities, but as we show below the density of safe-water options varies greatly. DASCOH is focusing its tubewell installations on communities with no access or with scarce access.

Factors determining access

On the explanatory side, we have measures for the socio-economic composition of the communities and for their location in the service-rendering system. Also we assume that neighboring communities share other common factors by their membership in the same local government areas. Each community belongs to exactly one of DASCOH's four working subdistricts (Upazila) within Sunamganj District, one of its 25 working Unions, and one of 225 electoral Wards.

The socio-economic composition was measured through a participatory wealth ranking exercise. Households were placed in three strata in each surveyed community: hardcore-poor, poor and middle-class / rich households[3]. This is a relative measure, with criteria plausibly open to local influences. In addition, households with members overseas were noted. Communities with more such households are likely richer, more demanding, and more capable of securing services (because they proved capable to overcome migration hurdles). Similar effects are expected of the educational level, which we measure as the ratio of adults with any amount of post-primary education to the number of households.

We measure the situation within the locational system of service provision through two indicators: distance to the nearest commercial center, and depth of tubewells. Commercial centers are either permanent clusters of shops (*bazar*) or weekly or twice-weekly livestock and artisan open-air markets (*hat*). Distance to the nearest such center bundles several factors that facilitate or inhibit services - the ease and cost of interacting with providers, the density of interaction with other consumers, the proximity to administrations that allocate government and NGO resources. These factors occur in diverse, but (for us) unobserved local mixtures, which limits the validity of distance, regardless of its precision, as a measure of locational disadvantage.

Depth of tubewells - we take the mean of the most shallow and the deepest wells reported by residents - closely determines the cost of safe water provision, and therefore also the effort to maintain hygienic latrines, which require a convenient water supply for flushing. The cost of water may impact also the access to services outside the WatSan domain. The effect may be indirect. It may work via irrigation and income from irrigated farming, and hence the ability to pay for services. Better water supply may make administrative centers more hospitable and thus may influence facility siting and staffing, and ultimately service delivery. While the exact processes remain hidden, we keep the distance to commercial centers and tubewell depth in our models for all four types of service access.

Equally hidden are the influences that being a member of a particular Ward or Union exerts. What does being in Union X do for the chance of people in village Y to have better access to, say, safe water? Three questions of interest, however, are open to statistical inquiry:

1. Do communities within one administrative unit significantly differ from those in other units? For example, after accounting for the measured socio-economic and locational differences, does Union A offer better post-primary education access than Union B does?
2. How does the variation across Unions compare to that across electoral Wards, and how do these effects compare with the effects of the factors measured in the villages? For example, regarding access to health care centers, is the simple distance to commercial

[3] The term "hardcore poor" is used in the governments' "Pro-Poor Strategy for Water and Sanitation Sector in Bangladesh" (GoB 2005: 3). "Extremely poor" and "ultra-poor" are other commonly used terms.

centers more instructive than sharing, with other villages of the same Ward, the same length of annual flooding and road disruption?

3. Are the effects of belonging to particular administrative units correlated across institutional areas? For example, if Union A indeed offers better education access, do its people enjoy better sanitation too?

We study those questions in the light of the overarching question that preoccupies us: How much is progress affected by wealth vs. poverty, and how much by favorable vs. adverse location?

The distribution of services

Sunamganj, like so many developing regions, is an area of great inequality. The inequality is manifest in access to services considered basic - water and sanitation, education and health care, among others. It is stark also in the underlying socio-economic conditions that in part explain the differences in service outcomes.

In three of the four service measures (water, sanitation and education), the average community enjoys low access. Access to health care, as much as the cost of transport to a point of diagnosis and drug sale validly measures it, is distributed more favorably for the majority of communities.

Table 1: Range of access to services

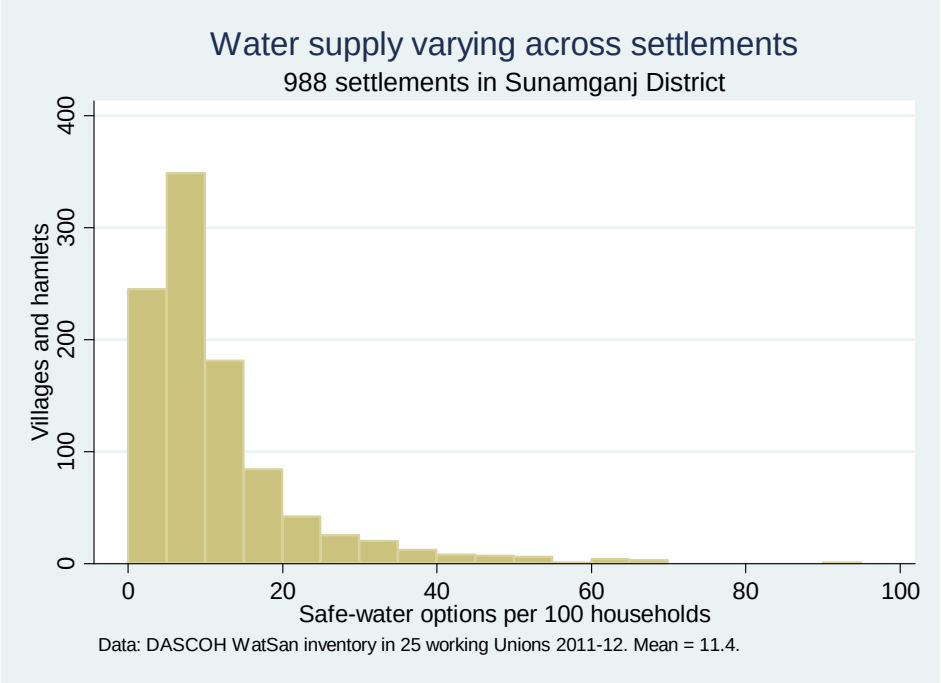
Service area	Community with .. value		
	lowest	mean	highest
Water			
Safe water options per 100 households	0	11.4	91.3
Sanitation			
Fraction HH using latrines:			
Hygienic latrines	0	0.05	0.75
Any type of latrine	0	0.38	1.00
Education			
Fraction adolescents with some post-primary	0	0.33	0.96
Health care			
Cost of transport to point of drug sale (Taka)	0	43.1	500

Notes:
Communities with valid data: 988 (latrines any type, education: 985)
Population-weighted means (education: by adolescents; others: by households)
Fraction HH using any type of latrine: see text on difficulty to measure seasonal use

The distribution of these indicators over the almost one thousand surveyed communities is concentrated on the lower values, for some more heavily (e.g., safe water, hygienic toilet,

medical transport), for others less so (toilets of any type, post-primary education)[4]. This is exemplified in this chart of safe water options per 100 households.

Figure 4: Histogram of safe-water option density



The values of this indicator range from zero safe water options (in six communities) to 91 per 100 households in the village of Jangalhati under Tahirpur Upazila. The mean is 11.4 whereas the typical value (median) is 8.1. In other words: Typically, 12 households share a safe-water point.

The shapes of the distributions of the other indicators are similar. Note again that in most indicators the concentration in the lower values reflect socially undesirable inequality among communities. In the case of medical transport cost, the same tendency is desirable; for most communities, the cost is in the lower range.

The modeling of variables with such one-sided concentration or heavy "skewedness" is demanding and sometimes suggests simplifications that produce approximate results. In a brief methodological appendix, we enumerate the major procedures used in the analysis. Here we present two such approximations: First, the correlations among access indicators. Because these are heavily skewed, we use a special measure that asks: if community A ranks higher on indicator X than community B, is it likely to rank higher also on indicator Y? We will make

[4] Statisticians, paradoxically, call a distribution concentrated on the left side, "positively skewed", "right-skewed" or "skewed to the right". The measure, "skewness", is dimensionless and independent of the scale of measurement. It is zero for symmetrical distributions (e.g. the normal distribution); it is 2.7 for the density of safe water options shown in the histogram.

repeated use of these so-called Spearman rank-order correlations (Wikipedia 2012). Second, the sources of variation in service access. Access differs between Upazilas, Unions, electoral Wards, and again within Wards (obviously, it also varies within communities, but because survey workers aggregated the data to the settlement level, we cannot describe differences within).

This table presents a matrix of Spearman's rank-order coefficients for our five service indicators.

Table 2: Correlations among access-to-service indicators

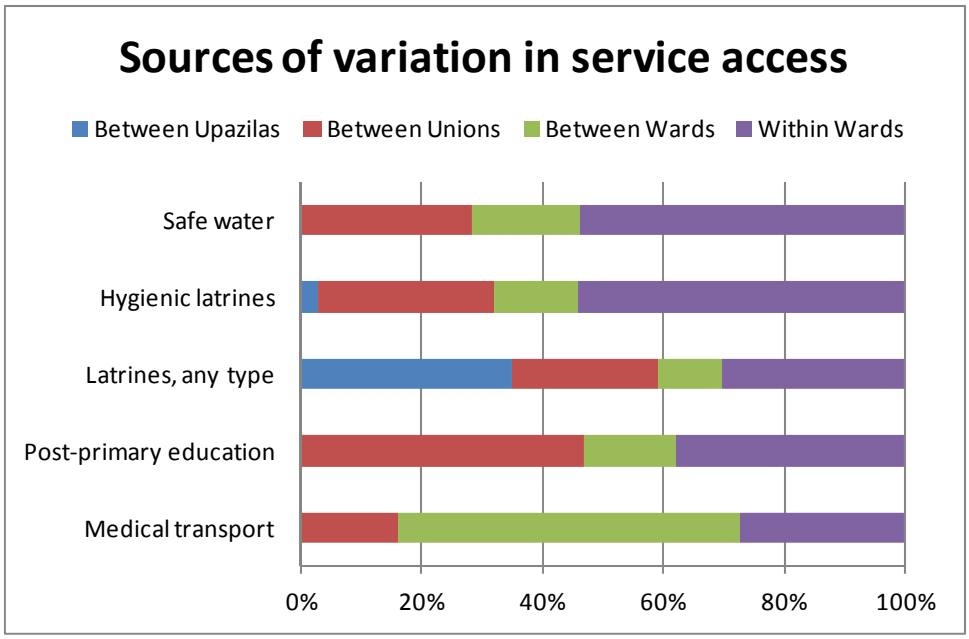
Indicators	Safe water	Latrines, hygienic	Latrines, any type	Education, post-prim.	Medical transport
Safe water	1.00				
Latrines, hygienic	0.58	1.00			
Latrines, any type	0.22	0.18	1.00		
Education, post-primary	0.23	0.23	0.14	1.00	
Medical transport	-0.09	-0.14	-0.18	-0.09	1.00
Keys to cell colors:					
Among WatSan indicators					
WatSan with education and medical					
Education and medical					

We note that only one coefficient is elevated - for the connection between safe water access and hygienic latrine use (+0.58). Apparently, to a fair degree these facilities are developed in parallel. The other coefficients are much smaller. Between WatSan and other institutional areas, we nevertheless note the weak correlations with the education of adolescents beyond primary school (with safe water and hygienic latrines, both +0.23). The correlations between WatSan and medical are negative, as expected (because we measure transport cost, not medical assets). But they are weak, so much so that we can doubt that the same causes work on WatSan and health care access. This, while far from being confirmed, is a noteworthy first indication of a relatively strong institutional autonomy of the WatSan sector.

Second, we turn to the sources of variability in each of the indicators. The percentages of the bar graph below are proportionate to the estimated variance that can be attributed to each hierarchical model - from Upazila to Union to electoral Ward to hamlet or village within a Ward[5].

[5] Most of the surveyed settlements are small hamlets (known locally as *hati*) within larger villages. For simplicity, we will henceforward only speak of villages.

Figure 5: Sources of variation in service access



We note that differences between Upazila are significant for fractions of households using latrines, and are barely noticeable for those having access to hygienic ones. They are insignificant in the case of safe water access, the education of adolescents and the cost of medical transport. We will therefore not include an Upazila level in our statistical model although we will present model predictions occasionally separated by Upazilas.

The Unions are the source of major variation in the education indicator whereas the electoral Wards are greatly determining of medical access. Finally, differences between communities within the same Wards are particularly strong for safe water and hygienic latrine access.

We will in later sections dissolve these constellations with the help of socio-economic and locational measures. At this point, we speculate simply that latrine use differs strongly among the four Upazila because of earlier sanitation programs that were concentrated in some places. The variability of adolescent post-primary schooling across Unions may be due to the location of high schools near Union headquarters, the differing willingness to send children there, and to success and failure in attracting and operating such schools. The great variation of medical transport cost among Wards (much more than among Unions and within the Wards) may be related to recent decentralization of government health care facilities. Finally, the dominant variation, within the same Wards, of safe water and hygienic latrine access may be due to the localized geological and topographic fabric of water sources.

[Sidebar:] Counting households that use latrines

The challenge to describe the task environment in Sunamganj shows up in something as simple and physical as latrines, one of the cornerstones of most WatSan programs, including DASCOH's. Some of these facilities are shared by more than one household; thus usage, not

ownership, is the meaningful criterion. Moreover, latrines come in a variety of physical makes and seasonal access. In the baseline survey that DASCOH conducted of a sample of 1,290 households in 86 small local communities in 2011, it distinguished as many as six levels of latrine use. Not surprisingly, these were found strongly correlated with household poverty, as this table shows.

Table 3: Toilet type, by poverty level

Toilet type (dry season)	Poverty level			Total
	Extremely poor	Poor	Middle-class and rich	
Open place	31%	16%	10%	22%
Unprotected hole or pit	12%	12%	7%	11%
Hanging	18%	28%	11%	20%
Ring slab (unsealed)	37%	42%	50%	41%
Ring slab (Sealed)	1%	1%	7%	2%
Sanitary	1%	1%	15%	4%
Total	100%	100%	100%	100%

Source: Baseline survey. Household sample (DASCOH and Benini 2011: 27). Hanging latrines are enclosures on stilts built in or near shallow water bodies. Sanitary latrines are sealed ring-slab latrines with offset pits.

For the purposes of the full-enumeration inventory in 2011/12, DASCOH simplified the typology to three levels. Households practicing open defecation were counted as "no latrine use". The range from unprotected holes and pits to unsealed ring slabs was fused into "unhygienic latrine use". Sealed ring slab and sanitary latrines qualified as "hygienic", on the assumption that only these practices bestow significant health protection. Only five percent of the households used a hygienic toilet, 33 percent used unhygienic varieties, and 62 percent defecated in the open.

The difference between sealed and unsealed ring-slab latrines is noteworthy for its connection with the history of sanitation programs. Between 2007 and 2012, the government and UNICEF, working through NGOs, spearheaded Community-Led Total Sanitation programs (CLTS) (Deak 2008) in two of DASCOH's for working Upazila, Salla and Tahirpur. CLTS emphasizes community mobilization over hardware support. Nevertheless, authorities in Salla and in some adjacent areas provided concrete rings and cover slabs; a significant number of households acquired these facilities. However, sealed latrines require bucketfuls of water to flush. Many users broke the seals. They did so chiefly due to the inconvenience of carrying and/or storing this much water, combined with a lack of awareness of the health effects of hygienic toilets.

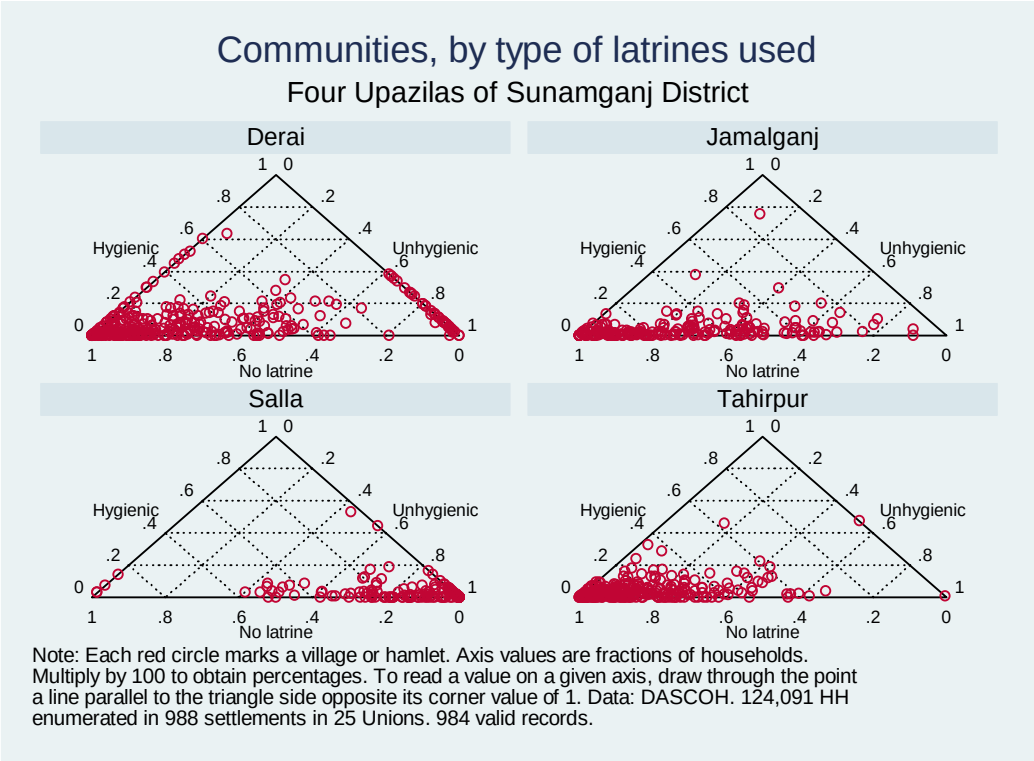
Also, during the monsoon season, a large fraction of the unhygienic latrines are submerged, otherwise not accessible, or not used in favor of defecation in flood waters.

From some of the communities with CLTS experience, the DASCOH field workers accepted their self-assessments that there were zero households left that did not use latrines. This biases the fraction of households using at least some form of latrine upward. We thus have less confidence in the statistics, and in our models built on them, of the penetration of communities with latrines of any type. This problem does not seem relevant with the much more restricted use of hygienic (sealed ring-slab and sanitary) latrines, most of which are used around the year.

Since the percentages of households using hygienic, unhygienic or no latrines always add up to 100, we can represent the distribution of surveyed communities regarding their sanitation in this

triplot. It is obvious that Salla is distinct from the other three Upazila, with most of its communities reporting fewer than 40 percent non-users. To a minor degree, a number of communities with zero non-users were reported also from Derai Upazila, most of them in a Union adjacent to Salla. From our statistical model of use of latrines of any kind, we excluded villages in Salla.

Figure 6: Latrine use, by type and subdistrict



Readers may find it hard to warm up to the arcana of latrine use. In survey terms, one might simply put some of them down to correlated measurement error - data collectors in one area treating seasonal use differently from other areas. However, such difficulties illustrate the fact that descriptions of the task environment depend on how categories are defined, shared and applied. Which categories prevail, and how they fluctuate in practical use, is decided not by a single NGO like DASCOH, but by the history of entire organizational fields such as the WatSan community of practice.

Explanatory variables

The indicators produced to explain variations in service access were enumerated earlier, in section "Factors determining access". Here we will give their basic descriptive statistics and explain why we transform their absolute values into four categories, i.e. four quartiles, from the lowest 25 percent of their values successively to the highest 25. The reason is that, very much like the access indicators, most of these explanatory variables have highly one-sided or "skewed" distributions. Using their absolute values would give undue weight to a few outliers at

the high end; breaking them down to quartiles loses some information, but mitigates the risk of being misled by the disproportionate influence of a few communities with atypically high values.

Table 4: Explanatory variables - descriptive statistics

Domains and indicators	Community with .. value		
	lowest	mean	highest
Community size			
Number of households	6	125.6	679
Household socio-economic composition			
Fraction middle-class and rich HH	0	0.25	0.97
Fraction HH with members overseas	0	0.05	0.77
Ratio of adults with some post-primary education to number of HH	0	0.19	1.21
Location			
Distance to nearest commercial center (km)	0	3.73	25
Depth of tubewells (range midpoint, feet)	45	443.2	725

Notes:
Communities with valid data: 988 (Depth of tubewells: 986)
Indicators not population-weighted

Two remarks are in order here. First, we do not use the information on the extremely poor in our statistical models. In the 988 surveyed communities, 35 percent of all households were rated extremely poor, 40 percent poor, and 25 percent middle-class or rich. The extremely poor thus are an important component, as is well known. However, the fractions of poverty ranks are constrained to sum to one, which implies that the percentages of extremely poor of and middle-class / rich households cannot exceed 100. This has adverse consequences when both fractions are included in the same model. For this and other reasons - the poverty ranking followed local criteria; the adoption of services is plausibly driven by the strength of the middle-class and rich group -, we use only the fraction of the middle-class and rich households as direct poverty measure.

Second, as mentioned, we transform the distributions into quartiles. We do this for all except tubewell depth. This one is known to be in close proportion with the installation cost of tubewells (each additional foot costs about Taka 60), and thus plausibly exerts a fairly linear effect on safe water and hygienic latrine access. Here we demonstrate the quartiles, as an example, of one variable, the fraction of middle-class and rich households in the community.

Table 5: Quartiles of the fraction of middle-class and rich households

Quartiles	Communities	Minimum	Mean	Maximum
1	247	0.00	0.08	0.14
2	247	0.14	0.19	0.23
3	247	0.23	0.28	0.34
4	247	0.34	0.44	0.97
All	988	0.00	0.25	0.97

We note that, as expected, the quartiles are of equal size, yet the length of the ranges that they cover varies, and so do the gaps between their means. The range of the fourth quartile runs all the way from 0.34 to 0.97 through its mean at 0.44 - the categorical transformation protects the model estimates from undue influence of the extreme values. The quartiles of the other variables do the same. As we shall see in the next section, the estimates are presented such that for each quartilized variable, the effects of quartiles no. 2, 3 and 4 are compared to the first.

[Sidebar:] Poverty and location in Sunamganj

"Poor areas, or only poor people?" Ravallion and Wodon asked in the title of their seminal study of the relationship between poverty and location in Bangladesh (op.cit.). As many would expect, their analysis confirmed the view that adverse geographic factors aggravate poverty beyond the level expected on the basis of purely household-level attributes.

In Sunamganj, poverty is almost universally high. Moreover, the distribution of residential and commercial land above normal flood level is patchy and fashioned by complex river and seasonal-lake dynamics. As a result, the connection is more difficult to unravel. In the villages surveyed during DASCOH's WatSan inventory, the relationships between socio-economic and locational factors are weak and highly variable across sub-units such as the 25 working Unions.

We expected to find that settlements closer to commercial centers had more middle-class and rich households. However, the correlation between the fraction of such households in the community and distance to the accustomed *bazar* or *hat* was only weakly negative (Spearman's rho = -0.10 for 988 settlements). Allowing that wealth rank criteria are open to local notions, we looked also at the correlation between distance and a uniformly defined poverty correlate, the fraction of households with members overseas. This correlation is slightly stronger, at -0.19.

Within sub-districts, the direction and strength of the relationship varies strongly. The greatest range is in Tahirpur: The correlation coefficient (middle-class / rich x distance) for the 21 villages of Balijuri is -0.40. For the 27 in Dokshin Bardal, it is +0.42.

A clear pattern is not obvious. Balijuri is on the main road to the district center. Here richer households may pay a premium to locate more closely to road and roadside markets, thus relegating poorer households to more remote communities. The same may hold for Unions in the northeastern parts of Jamalganj and Derai Upazila, close to the respective roads heading northeast and north to Sunamganj city. But in other places, this mechanism does not seem to

operate; thus in the Union that hosts the administrative center of Tahirpur Upazila (Saddar), the rich and middle-class tend to live farther away from commercial centers, if only faintly so.

Statistically, then, poverty and location - as measured by DASCOH - are almost independent. With the finer grain of household-level data, in ethnographic fieldwork, and in the everyday knowledge of DASCOH's frontline workers, it will not be difficult to establish stronger, if more intricate relationships. For this study of access to services, however, their apparent near-independence is a convenient finding; we need to worry less about multicollinearity.

Socio-economic conditions, location and access to services

This chapter analyzes how socio-economic and locational factors influence access to services. We proceed in three steps. First, we present the effects of the variables measured at the village level. Second, we compare the effects of those variables to the effects that the Ward-level and Union-level environment produces (for technical reasons we combine Upazila and Union effects). Third, we explore whether those various factors - from village to Ward and to Union/Upazila - have similar impacts across the various service areas - WatSan, education and health care. Again, we emphasize that the models of access to education and health care are for purposes of comparison with the WatSan sector only.

Village level effects

In previous sections, we introduced the socio-economic and locational variables that we use identically across service sectors, and how some of them are transformed into quartiles, to control outlier influence. For intuitive understanding, we table the *percent-wise increases or decreases* in the access-to-service indicators, depending on factor levels. These figures are derived from regression estimates, for which interested readers find the traditional output in the appendix.

The percentages shown here are expected changes in service access if the concerned contributing variable changes, and while controlling for the effects of all other variables. For most variables, the increase or decrease relates to the difference over the expected access for the first quartile. For example, by moving form a village with 8 percent middle-class and rich households (first quartile) to one with 25 percent (third quartile), and if *all other things remained the same*, we would expect households using hygienic latrines to go up, *on average*, by 121 percent. For the depth of tubewells, we calculate the expected change if the tubewell is deepened by one standard deviation (112 feet), which is typically how effects of continuous variables are compared.

Table 6: Effects of village-level variables

Access to services:	Safe water	Hygienic latrines	Latrines, any type (excl. Salla)	Adolescents in post-primary education	Medical transport cost
Influencing factors:					
Middle-class and rich					
2	12.5	62.3	20.8	13.3	2.0
3	24.7	121.3	30.5	12.3	4.9
4	50.0	155.9	54.7	14.1	7.5
Education level					
2	17.0	21.2	-0.8	12.8	-6.9
3	29.6	33.6	13.8	23.7	2.5
4	40.1	109.4	33.1	53.5	5.5
HH with overseas members					
2	5.2	34.5	-3.5	-8.4	-10.6
3	14.2	64.9	12.8	2.0	-2.5
4	45.2	123.1	17.7	1.3	-2.6
Distance to commercial c.					
2	1.0	-14.7	-3.3	-3.8	83.7
3	5.6	-32.3	4.7	-11.0	214.7
4	-9.3	-28.1	-12.0	-18.0	408.3
Tubewell depth					
Increase by one SD	-15.5	-12.3	7.4	7.8	6.8

Notes:
Percentage increases for quartiles 2, 3, 4 are relative to the first quartile.
For tubewell depth, they are relative to an increase by one standard deviation, which is 112.9 feet over all communities, and 120.3 feet when excluding Sulla Upazila.
Cells are colored yellow to green for increases, and orange to red for decreases.
For medical transport cost, the cell color ramp is reversed (higher cost is worse).

The results are plausible for some models, and less so for others. Most consistent with common-sense expectations - since we do not have a formalized pre-existing model - is the behavior toward hygienic latrines. Use rates soar as communities have more middle-class and rich households, have more adults with post-primary education, and more households with members overseas. They fall with greater distance from commercial centers, and with increasing depth of tubewells. The wealth rank and household members overseas sending money may chiefly determine the affordability of hygienic latrines. The education level and cultural norms adopted by members overseas may be responsible for the understanding of, and need for, hygienic practices. For this particular service, looking at all five variables, one is inclined to conclude that, at the direct village level, socio-economic factors are more powerful than locational ones.

Most of the effects on the density of safe-water options are similarly consistent with regards to common-sense expectations, but they are, surprisingly, much weaker than those operating on hygienic latrines. Increasing distance from commercial centers dips safe-water access only in the highest quartile, and not much (by 9 percent). Greater depth reduces access, presumably for simple cost reasons (more frequent failure in deeper wells would be an alternative explanation).

The picture that emerges for latrines of any kind is even weaker. This need not surprise us because the simple ones included in this definition cost much less, and therefore their usage rates are less sharply different on the observed factors. Note nevertheless the strange effect of tubewell depth. To a small, but nevertheless statistically significant degree, communities with deeper water tables tend to report higher latrine usage. Such small positive effects apply also to post-primary education and to medical transport cost. Tubewell depth must be correlated with an unobserved factor that confounds these effects. We cannot explain them.

Access to post-primary education of adolescents is driven most strongly by the education level of adults in the village. This effect is far stronger than those of wealth and distance from commercial centers. Note that the density of households with overseas members has a negative effect on post-primary education in the second quartile and statistically insignificant ones in the third and fourth. One may suspect that communities initially invest more in sending members to work overseas (for jobs that require little formal education). With increasing success they avail more education opportunities for their youth. Overall, with regards to village-level factors affecting post-primary education, socio-economic ones appear to be more influential than location, but the difference is less compelling than in the safe-water and hygienic-latrine models. After all, tubewell and latrine parts can be shipped to villages piecemeal whereas a secondary school is a lumpy institution, either present or absent in the village.

This applies all the more so to the cost of medical transport. Here the effect of distance to commercial centers (where presumably many government and private health care providers are located) reigns supreme over the socio-economic composition of local communities. Compared to the distance effect, the effects of wealth, education and overseas migration pale.

At this point we want to remind ourselves ones more these all are effects of *village* attributes - for households within a given villages, the relative effects may yet look different again. We do not have household-level data to resolve this question. What can be said with certainty, however, is that in terms of access to all services villages that are the farthest from commercial centers are disadvantaged. Similarly, villages with less favorable socio-economic indicator values - and that in most cases means: with higher poverty - are disadvantaged in their access to WatSan and post-primary education services. But the relative weight of socio-economic and locational factors varies among service areas. WatSan services, while clearly responding to nearby commercial centers and to shallow water tables, are the most drastically boosted by better socio-economics. In post-primary education, where one could quip "the young follow the old", the balance is already less tilted to socio-economics. And in access to health care, to the extent that transport cost discriminates, location matters most.

[Case study:] Poverty and location - through the lens of safe water provision

Water and sanitation advance and regress with the interplay between poverty and location as well as, not infrequently, local politics. The ups and downs in access to safe water that a small hamlet in Derai Upazila suffered illustrate this aptly.

Pota is a community of twenty households perched on a piece of government highland between two villages in Charnarchar Union. Traditionally, households drew water from rivers and flood zones (haor) during the monsoon, and from the tubewells of a neighboring hamlet during the dry season. That their land is owned by the government (known as khas land) is indicative of their poverty and marginal status.

In the run-up to the local government elections in 2011, Pota believed for a while that it would be allocated a tubewell. However, the outgoing Union Council chairman expected speed money, which the people were too poor to raise. With only few votes to gain from this small community, the running candidates were not particularly eager to help. To make matters worse, the people of Pota did not turn out to vote for the candidates favored by their neighbors and subsequently found themselves shut out from their accustomed dry-season water access.

The baseline survey later in the year gave them the opportunity to voice their plight. DASCOH took it up with the newly elected Union Councilors, and by December 2011 the people of Pota were collecting their water from their own tubewell.

This facility impacts the lives of the community beyond the mere provision of safe water all year round. Women and girls walking to the neighboring hamlet, lengthening the queue at the tube-wells, were not always welcome. Sometimes insults were hurled at them; the fear of violence would always linger. This situation was not at all atypical of villages in Sunamganj; Faisal and Kabir (2005: 182), arguing from a gender perspective, demonstrated that women in Sunamganj - wives, daughters and daughters-in-law who do most of the water-related chores - suffered higher than usual physical, social and security hazards.

In Pota, the new tube-well has drastically decreased the effort of collecting water. In our interview, Aysha Begum, a 45-year old day laborer, abandoned wife and mother of two daughters described her relief. Formerly, in the dry season, she would carry water in a vessel two or three times half a kilometer from the tubewell. Sometimes the younger girl, who had dropped out of school, would help. More than once, the owners asked them not to come again. Having no other choice, Aysha and her fellow villagers would show up again and plead.

Figure 7: Aysha Begum, tubewell user

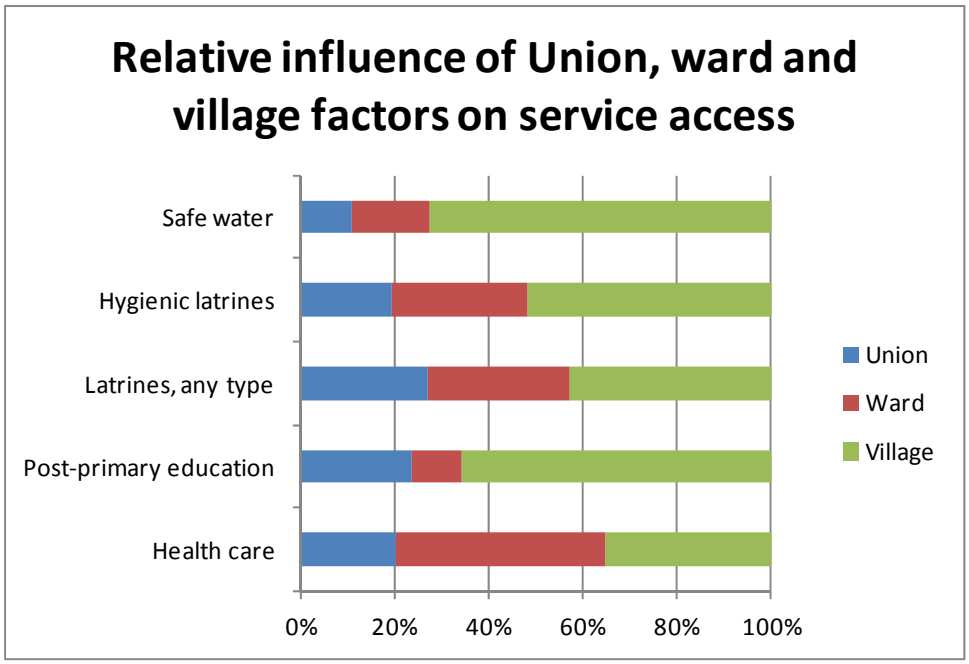
Nowadays, collecting water is a matter of a few minutes; older children can do this chore unassisted. Aysha finds it a bit easier to balance household work with her earning a living as a maid in better-off households and, occasionally, as a day laborer in fields and in stone-crushing sites. She has more time to visit her elder daughter, who was married in 2010.

Aysha is a "tubewell caretaker" trained by DASCOH to solve small technical problems ad-hoc. Larger problems are to be taken care of by trained local mechanics. Aysha and the other members of the "user group" are building a fund for future maintenance. They find it difficult to contribute because *"we all live from hand to mouth".* The immediate advantages of having their own safe-water source are obvious; the prospects of holding on to it in the longer term, if history is any guide, are less certain. Poverty and khas land status militate against it; conversely the habit of convenient, socially accepted access is a powerful incentive to keep it going by whatever means the community can muster.

Relative influence of Union, electoral Ward, and village

The effects described in the previous section were all effects of village attributes. Now we compare the relative influence of village factors with factors operating at the electoral Ward and Union levels. We do so using a simple model of influence shares as shown in this chart.

Figure 8: Relative influence of Union, Ward and village levels



Note: The length of the bar segments is proportionate to the variances of the Union and Ward random effects and of the village fixed-part linear predictor in each model.

The relative influence of factors at these three levels varies considerably by service area. The Union level is most influential in the distribution of latrines; we know that the Unions within two Upazila benefitted from particularly strong sanitation efforts. The electoral Wards differentiate most strongly in the access to health care; this is in part an artificial finding in the sense that medical transport costs for villages within the same Ward are similar. The observed village level variables exert their strongest relative influence on access to safe water and to post-primary education. However, in the case of safe water (and in sanitation), the differences between Wards are more important than those between Unions. In post-primary education, the opposite holds. Anecdotically, it is known that Ward-level plans make an impact on WatSan activity; thus differences in the quality of Ward representation may statistically show up in greater variation of WatSan results. Conversely, Ward committees may have lesser impact than Union Councils do, as regards opportunities for education.

From a WatSan agency's perspective, these findings make one pause. It is well established that Union and Ward-level initiatives make a difference in sanitation outcomes. What about access to safe water? It appears that progress in this area is far less malleable from those centers of planning and political process. Differences in safe water access are largely determined by our measured village attributes, none of which can be significantly changed in the short term. Here ultimately self-organized resource mobilization in the villages, on their own terms, may be needed for sustainable progress more than in sanitation or in curative health.

[Sidebar:] Managing contracts under poverty and locational pressures

Besides the uncertainty that local politics creates for water and sanitation projects - such as when the siting choices by Union Council leaders rouse suspicions of favoritism, necessitating a fresh round of negotiation -, progress can be hampered also by uncertainty in executing multi-party contracts. This is illustrated by the contracts for installing tubewells, into which DASCOH enters with Union Councils, user groups, and private contractors.

At first glance, such contracts reduce (rather than increase) uncertainty because they lay down the specific obligations of each party. Typically, the beneficiary households in the village, organized in a user group, collect and deposit 10 percent of the installation cost, which, in most cases, runs between Tk. 52,000 and Tk. 60,000 (approx. US$ 650 - 750). DASCOH's SDSD project underwrites the remaining 90 percent. The Union Councils do not contribute financially, but are involved in siting and supervision. The contractor warrants the tubewell for six months; the warranty is reinforced with "security money", generally 10 percent of the bill. This amount is released after a team formed of a Councilor, a DASCOH fieldworker, a Department of Public Health Engineering (DPHE) worker and a user representative certifies the well at the end of the warranty period.

However, unforeseen obstacles may overrun either time or cost (or both) budgeted for a tubewell project. Poor households may need more time to raise their expected contributions. Contractors may withdraw after initial negotiations, may be found unsuitable, or may clamor for higher payments invoking extra effort. A finished well may produce arsenic-contaminated water, in which case it needs to be relocated.

Figure 9: Tubewell-drilling team

(Ujangaon village, Atgaon Union, Salla)

More frequently, drillers hit rock, typically at depths of 300 to 600 feet, after spending considerable labor. In Tahirpur Upazila, several initial boreholes were abandoned when no water was found in depths between 500 and 720 feet. Drillers in some places in Derai Upazila struggled with gas pressure; in each of two sites, some 600 feet worth of PVC pipe were lost in the first attempt - in Chandpur village only the third drilling succeeded.

Initially, DASCOH offered contracts that had the contractors bear the drilling risk. They resisted, and eventually DASCOH assumed the cost of re-boring, in order to keep up with project targets. This, of course, re-creates the classic principal-agent problem (Fruttero and Gauri 2005), with the contractor knowing more of the borehole behavior than DASCOH does, necessitating closer supervision to avoid cheating. The user group serves as DASCOH's prime watchdog. Transferring the financial risk to poor beneficiaries would be unethical and impractical, and Councils are not willing to pick up cost overruns. Thus, the uncertainty, unbearable for the local actors, is resolved by an external player - the WatSan NGO - absorbing it.

Some risks can occasionally be mitigated by a networked approach combining actors of diverse strengths and local histories. Such coalitions - whether short-lived or more durable - may assess certain types of risk before any of its members becomes too far invested in particular projects. The risk sharing may be motivated by capacity, cost, knowledge management or division-of-labor concerns.

For example, in Derai Upazila, DASCOH initiated arsenic testing of all existing drinking water sources. In the event, the Upazila Council formed an "Arsenic Survey Committee", with DPHE and NGO participation, and paid Taka 40 for each test that local volunteers, selected by Union Councils, performed. DASCOH trained the volunteers and, together with Assistance for Slum Dwellers (ASD)[6] , provided test kits, supervision and sample re-testing. Among 4,589 wells tested, a small number – 129 - were found contaminated, of which 122 remained red-flagged upon re-testing. With hindsight, the risk seems almost negligible; yet, given the serious consequences of arsenic poisoning and the known prevalence of contaminated wells in other regions, such efforts are justified. Practically, priority is being given to the replacement of the identified bad wells, and to replicating the coalition approach to the other three Upazilas.

For us, here, the point is that risks with a potential to frustrate local projects can in part be assumed by larger networks.

Correlations between service areas

Finally, we turn to the question of how much the same forces that affect access in one area also determine access in others. To simplify matters, and because DASCOH is a WatSan promoter, we exemplify by three areas, two of which from WatSan. We compare how the indicators are correlated between each of the three pairs of service areas: water - sanitation, water - education, and sanitation - education. The table displays the correlations for the observed access, for the predictions from our regression models (and their residuals), but, most importantly for the effects of the socio-economic and locational factors that determine access to service. We focus on how these effects are correlated at the village, Ward and Union levels.

[6] A partner NGO of CARE's Shouhardo II project.

Table 7: Correlations among three service areas

Level	Between		
	Safe water and Hygienic latrines	Safe water and post-primary education	Hygienic latrines and post-primary education
Observed access	*0.58*	*0.23*	*0.23*
Village effects	0.90	0.64	0.64
Ward effects	0.45	0.23	0.13
Union effects	0.69	0.22	0.23
Predicted access	*0.77*	*0.31*	*0.33*
Residuals	*0.43*	*0.12*	*0.13*

Notes:
From multilevel mixed-effects Poisson regression models. Spearman rank-order correlations.
Observations, predictions and residuals are fractions (of households, resp. of adolescents).
Village effects are fixed-part linear predictors; Ward and Union effects are random effects.
N=25 Unions, 225 Wards, 986 villages.

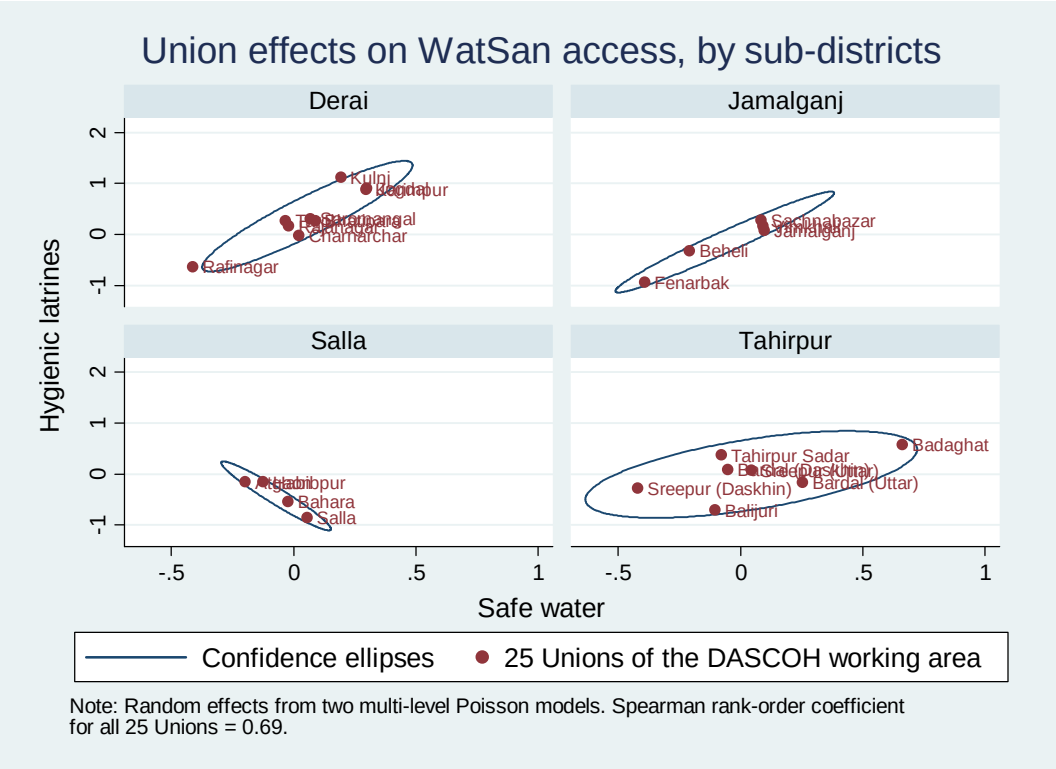
All correlations are positive. They are stronger between safe water access and hygienic latrine use than between either of these and the access of adolescents to post-primary education. This holds for all levels. For the village effects, the very high correlation (0.90) is not surprising; we had earlier seen (Table 6) that the effects of the socio-economic factors and of tubewell depth were similarly directed for safe water as for hygienic latrines (the effects of distance to commercial centers agree less).

Of special interest, however, are the correlations at the Ward and Union levels. For these we do not have observed variables that would let us expect correlated effects one way or another. Yet, between safe water access and hygienic latrine use, the 225 Wards show remarkably (0.45), and the 25 Unions show strongly (0.69) parallel effects. In other words, a Union with favorable conditions for safe water promotion will tend to favor also greater use of hygienic latrines, and vice versa. The correlations of Ward and Union effects between WatSan services and post-primary education are much weaker and, for the small sample of 25 Unions, not even significantly different from zero. But the pattern is the same, if to a weaker degree: for example, a Ward with a better climate for safe water access will tend to give its adolescents somewhat easier access to education than a Ward with less favorable disposition. The mechanisms favoring these parallel tendencies are not obvious from our data; they may be rooted in local activism, or in the history of government and NGO initiatives, favoring some areas more than others.

So far, this exposition has been somewhat abstract and limited to correlation statistics, behind which readers may not find much palpable matter. The interplay between the effects on service access is best visualized graphically; and for this purpose we chart the effects that the Unions have on safe water access and on hygienic latrine use. As we have seen, these effects are

strongly correlated (0.69). In this graph, we show the effects before exponentiation (so that not only the extremes are visible); in the text we will give two examples in plain percentages.

Figure 10: Correlated Union effects on safe water and hygienic latrines



Note: Random effects from two multi-level Poisson models. Spearman rank-order coefficient for all 25 Unions = 0.69.

When we break the correlation down by the four Upazila, a highly differentiated picture emerges. Salla and Tahirpur have a history of strong NGO action in WatSan. In Salla, this has leveled the playing field among its four Unions; the differences in Union effects are relatively small, as seen by the size of the ellipse around the points. If at all, the correlation within Salla would be negative, but the differences are too small to make this a finding of interest. Within Tahirpur, by contrast, Union effects on safe water access vary widely. There is a positive correlation, but it is due chiefly to the eccentric positions of two Unions, Sreepur and Badaghat.

Derai and Jamalganj Upazila are not known for a similarly extensive NGO history. Their Unions, if you will, "were more left to themselves". They had time to diverge in the strength of their developmental conditions, with some Unions presenting a more favorable environment, and others less so. Therefore, the correlations here are stronger (the ellipses have a more narrow shape). While the effects on safe water do not vary as widely as in Tahirpur, the differences in sanitation effects are remarkable. Taking the example of Kulnj Union in Derai, its effect on hygienic latrines (1.12) boosts usage in its villages by (exp(1.12) - 1) * 100 = 206 percent relative to the mean of the 25 Unions. On the other extreme, Rafinagar's conditions are such that it depresses latrine use to (exp(-0.63) - 1) * 100 = 47 percent.

Note that these tendencies are *relative* within the group of 25 Unions; their averages for the 25 are zero, by design. The point is that a favorable environment for safe water access tends to occur in Unions that offer favorable conditions for hygienic latrines as well - and vice versa. This is so also in the relationship between WatSan and education, but to a much weaker degree.

Note again that we speak strictly of Union-level factors, not of the specifics of the villages within. The Union effects are net of the effects of the socio-economic and locational effects of the villages (and also of the Ward effects). They reflect conditions that apply to the entire Union as such - stronger or weaker performance of the Union Parishad, political influence with Upazila and district administrations, vibrancy of the commercial centers, and the local histories of government and NGO programs. Within the WatSan sector, the Union effects move in parallel. Between WatSan and the education sector, this relationship is still positive, but weaker. This is an indication that the different WatSan activities cohere while the sector enjoys considerable autonomy vis-à-vis others. This is important for DASCOH, with its orientation towards working with multiple stakeholders, and its need at the same time to advance WatSan activities by its own targets.

Discussion

Our analysis has made three types of comparisons:

1. We have considered how access to services in water, sanitation, post-primary education and health care varies alongside conditions in the villages. Our data allows us to distinguish between poverty and two of its correlates (education, overseas employment) on one side and locational factors (distance to commercial centers, depth of tubewells) on the other.
2. In the vertical dimension, we compare the relative strengths of village, electoral Ward and lowest-level local government (Union) factors on services. In one way, these denote geographical areas. In another, more important sense, they are the seats of institutions that deliver, or influence the delivery of, services. In the Wards, elections produce Union Councilors who are more or less apt to direct services to their constituents. In the Unions, Council competency, political clout with Upazila and district administrations, commercial vibrancy and other factors that are not directly observable affect service outcomes.
3. Those effects, however, are different from one service area to others. We compare how they are correlated within WatSan, and between WatSan and post-primary education.

Between villages

Our main finding regarding village-level factors has been that for WatSan outcomes the socio-economic effects are stronger than locational effects. For post-primary education access, that is still true, but location is slightly more important (distance to commercial centers, some of which host high schools, matters). For health care access, location dominates. This is due chiefly to our incomplete measurement of health care access, limited to the cost of medical transport.

Village, Ward and Union

When we compare the relative strength of village, Ward and Union-level factors, we find considerable variety across service areas:

Village-level factors are particularly strong in their effects on safe water and post-primary education.

Ward-level factors strongly determine medical transport cost. This reflects both the siting decisions for health care facilities and geographic circumstances, such as when villages are cut off by seasonal flooding, and patients are evacuated by hired boat. Ward-level factors have considerable influence also in sanitation. This may be so because drives to build latrines were locally clustered under programs such as "Community-Led Total Sanitation".

Finally, the strongest Union-level effects, compared across service areas, are seen in the provision of latrines of "any type". This holds even after excluding Salla Upazila (where data collectors applied a definition of "latrine use" that was too liberal). This Union influence reflects sanitation efforts that were strongly promoted in some Upazilas, by government agencies as well as NGOs.

As noted earlier, many recipients of subsidized elements degraded their latrines because they could not fetch the water to flush. As a result, when we look at latrines that are hygienic only, we find that the Union effects have to an extent been pushed back by village effects. This is not an issue of poverty versus location, but rather one that pits policy versus poverty and location.

Post-primary education too responds to Union-level factors to a modest degree, plausibly because Unions differ in their ability to build and operate high schools. By contrast, Union-level factors have a surprisingly small effect on the provision of safe water. We will revert to this.

Between service areas

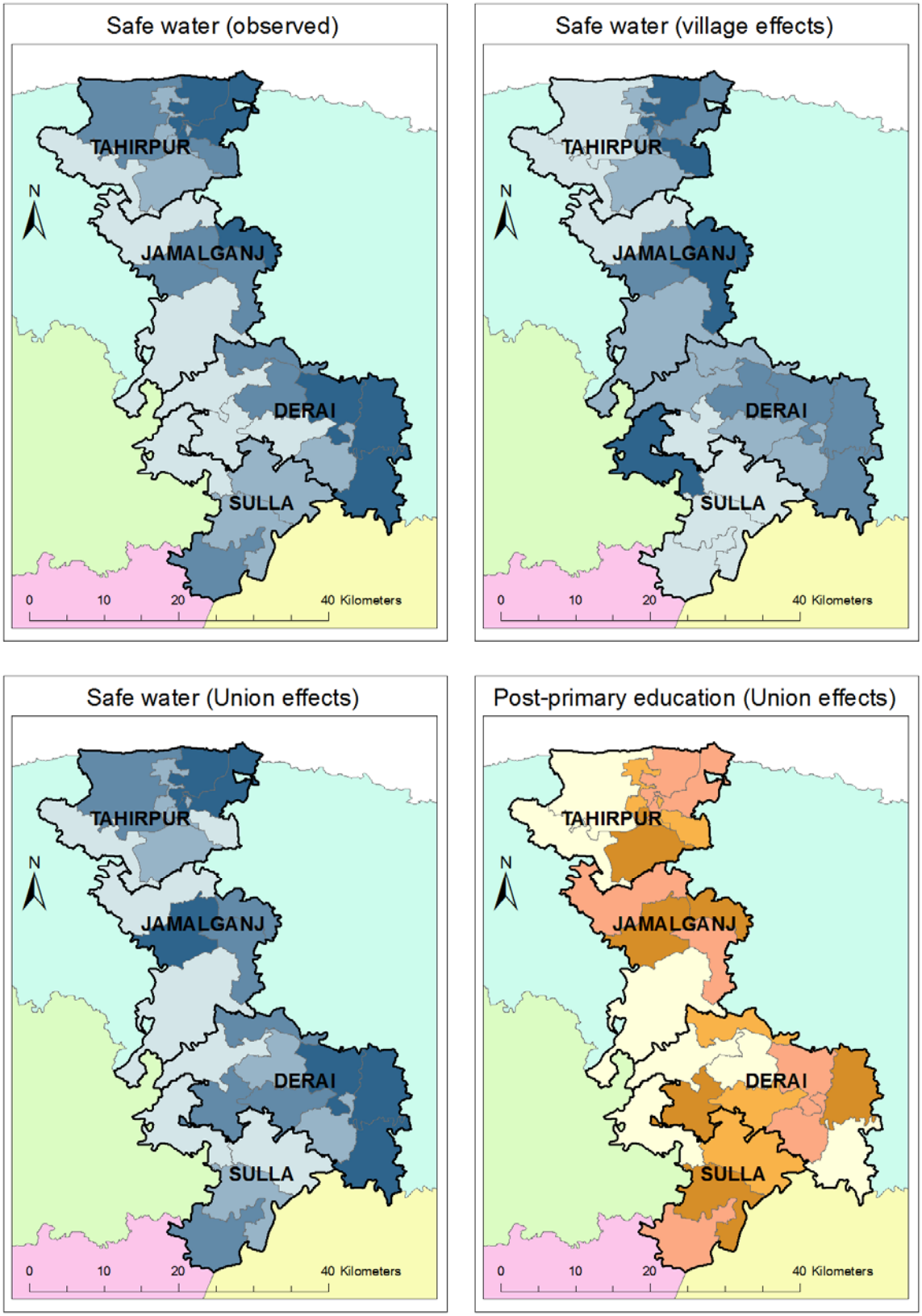
The effects of villages, Wards and Unions are strongly correlated between safe water access and hygienic latrine use. Village effects between WatSan indicators and post-primary education are strongly correlated; for Ward and Union effects, the correlations are weak. The correlations of all level effects between health care access and other service areas are weak.

[Sidebar:] A spatial perspective on village and Union effects

At various points of the analysis, we have made statistical comparisons of the effects at various levels - village, Ward, Union - estimated on access to services. The relationships among those levels are administrative - villages belong to Wards, Wards to Unions. Otherwise we did not consider geography.

The maps on the next page exemplify a geographical perspective on the 25 Unions in the four sub-districts in which DASCOH is working in Sunamganj.

Figure 11: Safe water access in the 25 working Unions



In each of the four panels, instead of a defined scale in the map legend, we simply arrange the Unions in ascending order in the variable of interest. Then we form four groups of roughly equal size (quartiles). In each map, darker hues stand for higher values (in the lower right panel, the order is from white to pink to yellow to brown).

We start with the upper left panel, which maps out the intensity of access to safe water, averaged from villages to Unions. It appears that in Tahirpur, Jamalganj and Derai, safe water access improves as we move from west to east (from left to right). This is correct to the point that the better served Unions are those closer to main roads connecting to the district headquarters and to the city of Sylhet. Salla, with fewer developed roads, follows a different pattern. Road access and distance to urban centers are important locational factors.

The observed pattern is explained by a combination of effects from the socio-economic and locational attributes of the villages as well as from Union effects that are independent of the villages (Ward effects cancel out within each Union). By comparing the left panels, one can see that the observed access to safe water follows the Union effects closely. The correlation between observed access and village effects (the two upper panels) is weaker. However, this is so because in both the values were averaged to the Unions, thus losing a great deal of information. In some areas, village and Union effects counteract each other; for example, in the northwestern Union of Salla (known as Atgaon), the villages have socio-economic and locational advantages letting us expect high ratios of safe-water options to households. However, Union-level circumstances of unknown nature depress the outcome in the same villages.

Finally, we arrange Union effects on safe water access and on the participation of adolescents in post-primary education side by side (the two lower panels). Here two there is some mild correlation (the Spearman-rank order coefficient, as reported earlier, is +0.22). Thus, in Atgaon, mentioned in the previous para, Union-level conditions are not good for adolescent education either.

Another way of talking about Union effects is to say that, for example, "the villages in Atgaon, on average, have not made as much progress as one might expect at their level of resources". In this reading, Unions are seen as catalysts aiding the conversion of village resources into service access - some Unions are better catalysts than others.

The major point is that while it is easy to spot a few Unions that are favorable to both safe water and post-primary education, and some others that inhibit both, there is a lot of middle ground in which the effects on safe water and on education differ. Overall the correlation is positive, but weak. At the Union level, the WatSan sector (as shown by the safe-water access pattern) enjoys a fair measure of independence.

Conclusion

Our data were collected in a complete enumeration of households in the 988 settlements that fill the DASCOH working area in Sunamganj. The estimates thus have zero sampling variance. The validity of findings is limited only by model misspecification, defective constructs and measurement error. For example, measuring access to health care only by the cost of medical transport is unsatisfactory. It is a safe bet that, had mortality been monitored, stronger poverty

effects would have shown up than in our proxy model. Measurement error was present in the counts of households using any kind of latrine; we were able to isolate it to one of the four sub-districts and exclude this in the concerned estimate. Another limitation is geographic. Generalization to other regions in Bangladesh or to an imagined superpopulation of generic poor rural communities anywhere is problematic; in such a perspective this WatSan inventory would amount to a cluster sample with large clusters (approx. 250 settlements in each of four subdistricts), and hence with a considerable design effect.

Yet even in the face to those reservations, this study is extraordinary. It brings together data from a large number of communities; this allows us to statistically segregate the effects of various factors.

Assuming that the findings are robust, as far as the DASCOH working area in Sunamganj is concerned, what do they mean?

Poverty, location as well as institutions

The most important observation is that we should not look only at poverty and location. Rather, our focus should be on poverty, location as well as institutions. The absolute strength of socio-economic factors at the village level and the relative strength of all village-level effects compared to Ward and Union effects indicate that poverty is the strongest determinant of access to services. However, this is modified by the significance of village-level locational factors in health care access and by Ward-level factors in sanitation and again in health care. These Ward factors are part institutional - the Wards have a function in Union budget plans, including for the projects that DASCOH supports -, and part locational. The institutional and the locational qualities are difficult to separate, but it stands to reason that "remoteness" applies primarily to villages, to a lesser degree to Wards, and even less to Unions and sub-districts as a whole. The opposite is true of "formal institutions".

Doubtful sustainability

The second observation has already been made in the sections above. Most socio-economic and locational circumstances of villages are not open to rapid change from the outside, and some not at all. It is easier to fashion Union and Ward-level factors, by institutional and program designs and by appropriate resourcing. However, these factors are not equally strong, relative to village-level factors, for all service areas. This has implications for the sustainability of programs. In DASCOH's case, safe water and sanitation meet with somewhat different forces. In Sunamganj, Unions and Wards, compared to villages, have had relatively stronger effects on the expansion of latrine use than on safe water access. This is not quite true; as we have seen, the village "came back with a vengeance", with many poor households breaking their latrines open. Yet, even then, the Union and Ward effects are stronger than in the case of safe water provision. In this subfield they are particularly weak. This puts a question mark on the ability of WatSan NGOs like DASCOH to ensure that safe water sources can be properly maintained. DASCOH is creating systems with Union Councils and village communities to facilitate long-term

maintenance. But such systems will struggle in communities where poverty, remoteness and low water table are pronounced.

One may argue that such fears have been refuted by progress in other domains. In post-primary education, the relative strength of village-level factors is almost as high as in safe water provision. Regardless, education has seen widespread expansion, and Union and Ward effects are less remarkable exactly because it has been expanded almost everywhere. But, as is well known, the education system struggles with quality issues. These are, for our argument here, the equivalent to maintenance issues in water and sanitation. There is no easy doing away with the consequences of poverty and location.

Autonomy of the WatSan sector

The third observation is more optimistic. The effects of villages, Wards and Unions, at each level, are similar for safe water provision and for hygienic latrine use. The correlation is the strongest at the village level, strong across Unions, and considerable across Wards. Compared to that pattern, the correlations between WatSan access on one side and post-primary education access on the other are positive, but much weaker. They are even weaker between WatSan and health care access (not shown in our table for space reasons).

This means two things:

Program coherence: WatSan providers like DASCOH can pursue a coherent program. Unions, Wards and village communities that are more receptive to sustainable safe water provision will tend to be the ones more receptive also to sustainable hygienic latrine use. The word "sustainable", twice used, is justified because the WatSan inventory recorded installations that have existed for some time, not only those freshly built with DASCOH support. For the longer run those correlations imply that advances in safe water and those in hygienic latrines will reinforce each other at all levels.

Local opportunities: It is obvious that this assumption is contradicted by what we just said two paras above about the greater resistance that sustainable safe-water provision will face from village conditions. At this point the weak correlations between WatSan and other service areas matter: At the Ward and Union levels, WatSan providers enjoy considerable institutional autonomy. The conditions that favor or hamper them are not the same that affect educational institutions or health care services. These domains are conditioned by different institutional networks and different program logics (although Union Council chairpersons, Upazila Nirbahi Officers and members of parliament may wield influence across domains, ultimately siting decision for new schools or new health care facilities are made by the concerned line ministries). There is little in the way of a generalized disposition of certain Unions to all kinds of development, and of universal resistance by others. Favorable environments vary from one sector to the next. If WatSan providers can match their programs with receptive Union Councils and Ward committees, they should be able to compensate in some degree for the obstacles that poorer and remote communities face.

Then, if and when advances in safe water and sanitation prove sustainable, the question will be how they in turn help to reduce poverty. This is beyond this study. In the meantime, DASCOH is addressing its water and sanitation objectives with a series of instruments. These include specific agreements with Union Councils, support to the Ward and Union planning mechanisms and to local user committees, and training and supervision of local contractors. They aim to make every local project more dependable and less vulnerable to the effects of poverty and isolation.

Figure 12: Arsenic test performed at a newly installed tubewell

Atgaon Union, Salla Upazila, 2011

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Appendix

Overview of statistical models

The distributions of all the service access variables - which are the dependent variables in regression models - and of most explanatory variables are highly skewed. We use Spearman rank-order rather than Pearson moment correlations to measure the strength of their associations. For intuitive comparison and for outlier control, we categorize all but one of the explanatory variables by quartiles.

Except for the number of safe water options in the village, the service indicators are not true count variables. The number of latrine-using households is bounded by the number of all households. The number of adolescents in school is bounded by the number of all adolescents. The cost of transporting a patient to a point of diagnosis and drug sale is expressed in a positive rational number. Nevertheless, following Nichols (2010), we use multilevel mixed-effects Poisson regression (*xtmepoisson* in STATA) models to estimate fixed effects of village covariates as well as Union and Ward-level random effects. The choice is motivated by the need to estimate the effects of 225 Wards, which exceeds the capacity of fixed-effects estimators. We accept that for a small number of villages, the predicted fractions of latrine users or of adolescents in school are greater than one. We use the natural logarithm of the number of households, respectively the number of adolescents 12 to 18 years' old, in the village as offsets in water, sanitation and education models. In the medical transport cost model, the coefficient is free. The output is tabled further below.

In preparation for the regression models, we estimated variance components in service access indicators that we transformed to their normal scores for this purpose. Variances were computed between Upazilas, Unions and Wards and within Wards, using STATA's *xtmixed* routine (Marchenko 2006). In Figures 5 and 8, the sums of the estimated variances were scaled to one. Between-Upazila variances disappeared except in latrine use fractions; consequently, we eliminated the Upazila level from all *xtmepoisson* models.

For control purposes, we also estimated fixed-level models with Unions, leaving out the Wards. We used negative binomial regression for the number of safe water sources per 100 households. We used the variant of generalized linear models recommended by Papke and Wooldridge (1996) for dependent proportions to model the use of latrines and adolescents in school. We used the same approach to estimate effects on medical transport cost, after scaling its range to [0, 1], then re-scaling the predictions.

Multilevel mixed-effects Poisson regression models

Table 8: Coefficients and statistics of the Poisson regression estimates

	Safe water			Hygienic latrines			Latrines, any type (excl. Salla)			Adolescents in post-primary			Medical transport cost		
	Coef.	SE	P>|z|	Coef.	SE	P>|z|	Coef.	SE	P>|z|	Coef.	SE	P>|z|	Coef.	SE	P>|z|
Variables															
Middle-class and rich															
2	0.118	0.031	<0.001	0.485	0.053	<0.001	0.189	0.022	<0.001	0.125	0.022	<0.001	0.020	0.017	0.226
3	0.221	0.031	<0.001	0.795	0.053	<0.001	0.266	0.023	<0.001	0.116	0.023	<0.001	0.048	0.017	0.005
4	0.406	0.032	<0.001	0.940	0.056	<0.001	0.436	0.025	<0.001	0.132	0.024	<0.001	0.073	0.018	<0.001
Education level															
2	0.157	0.034	<0.001	0.192	0.054	<0.001	-0.008	0.023	0.734	0.121	0.021	<0.001	-0.072	0.018	<0.001
3	0.259	0.038	<0.001	0.290	0.060	<0.001	0.129	0.028	<0.001	0.213	0.025	<0.001	0.024	0.022	0.258
4	0.337	0.044	<0.001	0.739	0.067	<0.001	0.286	0.033	<0.001	0.429	0.031	<0.001	0.053	0.025	0.033
HH with overseas members															
2	0.050	0.030	0.098	0.296	0.059	<0.001	-0.036	0.027	0.178	-0.088	0.020	<0.001	-0.112	0.017	<0.001
3	0.133	0.033	<0.001	0.500	0.062	<0.001	0.120	0.030	<0.001	0.020	0.023	0.383	-0.025	0.017	0.136
4	0.373	0.044	<0.001	0.802	0.074	<0.001	0.163	0.035	<0.001	0.013	0.028	0.654	-0.026	0.024	0.277
Distance to commercial center															
2	0.010	0.027	0.719	-0.159	0.038	<0.001	-0.033	0.021	0.106	-0.039	0.020	0.049	0.608	0.021	<0.001
3	0.054	0.039	0.160	-0.390	0.069	<0.001	0.046	0.035	0.181	-0.117	0.031	<0.001	1.146	0.028	<0.001
4	-0.098	0.049	0.046	-0.330	0.089	<0.001	-0.128	0.043	0.003	-0.199	0.037	<0.001	1.626	0.035	<0.001
Tubewell depth															
Mean of min and max in hamlet	-0.0015	0.0002	<0.001	-0.0012	0.0004	0.001	0.0006	0.0002	0.001	0.0007	0.0001	<0.001	0.0006	0.0001	<0.001
Auxiliary parameters															
Number HH, resp. adolesc. (ln)	1.000 (offset)			1.000 (offset)			1.000 (offset)			1.000 (offset)			0.008	0.012	0.503
Constant	-2.243	0.116	<0.001	-4.094	0.218	<0.001	-2.156	0.148	<0.001	-1.695	0.133	<0.001	2.306	0.129	<0.001
Random effects															
Union (standard deviation)	0.262	0.047		0.581	0.099		0.513	0.089		0.547	0.082		0.469	0.084	
Ward (standard deviation)	0.329	0.020		0.702	0.045		0.538	0.031		0.366	0.020		0.701	0.039	
Statistics															
N	986			986			800			983			986		
Likelihood	-3423.7			-2950.2			-5032.5			-4519.7			-5457.8		
Wald	483.28			871.87			713.06			453.97			2545.5		
Spearman obs. vs. mu	0.81			0.78			0.80			0.83			0.93		

Note: Numbers 2, 3, 4 under "Middle-class and rich", "Education level", etc. refer to quartiles. The first quartile is the reference.

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